Influence of intellectual capital on product and process innovations

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Abstract
On a large GMRG database containing 761 companies influence of four components of intellectual capital (IC) on product and process innovation are researched using structural equation modeling. Findings show that IC largely influences product innovation, but indirectly also influence processes. Relationships among IC components on innovation activities are researched.

Keywords: Intellectual capital, product innovations, process innovations

Introduction

Product and process innovations are often conceived as distinct phenomena that contribute to organizational competitiveness and growth in different ways. Product innovations are pursued to respond to customers' demand for new products or executives' desire to capture new markets, whereas process innovations are pursued to reduce delivery lead-time or decrease operational costs (Damanpour 2010). Damanpour (2010) in his literature review finds ample evidence that researchers research product and processes innovation separately, but he arguments for the parallel investigation: "An alternative and less researched view suggests that innovation types are complementary and each type cannot be truly understood without an understanding of its relationship with the other type."

Kraft (1990) way back in 1990. argued that product and process innovations are not independent of each other, and stated that manufacturing of new products will only be possible if a new process is implemented. But he also argues that new process technology will not lead to new products.

Goedhuys and Veugelers (2012) using data from World Bank ICS prove that innovative performance is an important driver for firm growth. Growth is achieved through innovation (Darroch and McNaughton (2002)) and Wu et al. (2008) state that intellectual capital is a significant source of competitive advantage and a driving force for innovation. There is ample evidence that intellectual capital influences innovation (Subramaniam and Youndt, 2005; Lee et al., 2011; Kohan et al., 2014; Ahmadi et al., 2012; Sharbary et al., 2010; Chen et al., 2006; Hsu

and Fang, 2009; Kalkan et al., 2014; Alegre and Chiva, 2008). However, Menor et al. (2007) are the first authors dealing with how intellectual capital influences product and process innovations and what are interrelations between intellectual capital components, presenting a significant contribution to the study of the product-process connection.

But the problem is the definition of intellectual capital. So far, current literature deals with three component model of intellectual capital. Bueno et al. (2004) analyzing the development of intellectual capital research finally concluded that it should be a four component model, however they did not test the model, rather only proved that social capital has positive influence on innovation.

Therefore, our study addresses the found gaps in literature dealing with intellectual capital by proving on a large database that it is in fact a four component construct. Secondly, in lens of a four model intellectual capital constructs, the paper finds the interrelations between intellectual capital components and finds which ones contribute to process, and which ones to product innovation. This work is not a replication of the Menor et al. (2007) study, because their definition of intellectual capital has only three components and not in line with current definitions of intellectual capital components. Finally, a significant contribution is evident through proving hypotheses on a large Global Manufacturing Research Group database containing 761 manufacturing companies from 14 countries, of which some are developed and some developing.

Theoretical background

Intellectual capital

Bueno et al. (2004) nicely describe the evolution of the concept of intellectual capital. First was the Skandia model that encompassed only human capital and structural capital. Then in 1998. Intellectual model was presented having three constructs human capital, structural capital and relational capital. Then in 2001. KMCI model was popularized which had three components; human capital, social capital and structural capital. However, Bueno et al. (2004) commenting this third model say that it was largely based on Nahapiet and Ghoshal (1998) model with substitution of the relational capital with social capital. Bueno et al. (2004) this social capital divide into intra-social capital and inter-social capital. Their simplified model of intellectual capital is presented in Figure 1.

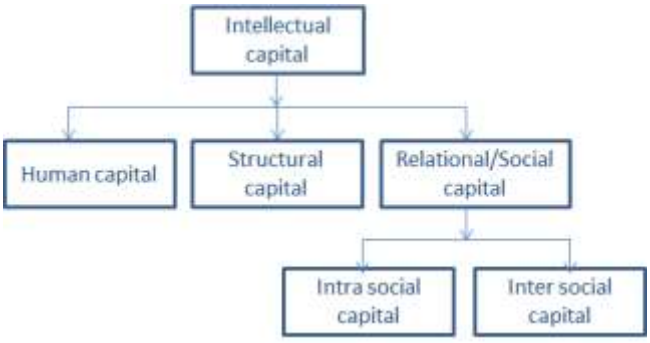

Figure 1 - Simplified Bueno et al. (2004) intellectual capital model

Human capital

Human capital is rooted in a certain way in the talent of employees. Human capital consists of components such as knowledge, expertise, skills, experience, competence, creativity, teamwork capacity, loyalty, training and education, problem-solving capability, attitude, loyalty and the motivation of people. Therefore, human capital consists of all the tacit knowledge embedded in the company (Sydler et al., 2014).

Structural (organizational) capital

Structural capital is the intellectual asset that remains when employees leave the company; hence, structural capital is independent of individuals and is generally explicit. It results from a knowledge spiral when implicit knowledge reaches the organizational level. Structural capital is created by containing and retaining knowledge to become company property. Structural capital belongs to the organization as a whole and can be reported and shared and includes intellectual properties consisting of patents, licenses, trademarks (Sydler et al., 2014).

Relational/Social capital

Social capital is not merely networking connections. Subramaniam and Youndt (2005) for example state that social capital requires the development of norms that facilitate interactions, relationships, and collaboration. According to Lee et al. (2011) social capital is defined as knowledge and learning capability embedded within informal interactions among individuals. However they also mention studies that divide the social capital into two groups: "Aspects of social capital have been operationalized in two ways: (1) the network structure of relationships, and (2) particular relations people have via interactions, such as feelings of gratitude, respect, and friendship, trust, norms, collaboration and obligations". Martínez-Torres (2006); Hsu and Fang (2009); Sydler et al. (2014) instead of using the term social capital they term it relational capital and define it as relationships the firms have with outside partners. Also it should be noted that social capital should not exclude good cooperation and knowledge exchange within the company, and concentrate only on outside of the company knowledge sharing. Therefore in this work social/relational capital is divided into intra social/relational capital and inter social/relational capital.

On grounds of work of Bueno et al. (2004) a four dimensions intellectual capital is used. The internal social capital construct describes internal facilitation of knowledge exchange (under assumption that individuals in the same company have similar values and norms and Lee et al. (2011) call this component information sharing quality). External social capital is capital that is obtained through cooperation with outside partners, but where shared norms have to be established.

Relational/social capital has to be divided into inter and intra-relational/social capital because of the simple fact that those two relationships lie on different motivations of employees. Internal social capital is a relationship between employees working in the same company. They cannot chose whom to work with, rather have to find a way of effectively communicating with coworkers. The effectiveness of their communication will be largely influenced by company's culture and upper level management commitment to enhance this communication by installing appropriate incentive schemes. By contrast, external ties of employees with outside partners are largely a voluntary choice. Either, they are connected privately or they chose the partner on their

judgment that this outside partner can be trusted. Putting these two components in the same construct will distort results, and it has to be also mentioned that their roles are completely different as the results will show.

Impact of intellectual capital on product and process innovations and hypotheses

Product innovations are defined as new products or services introduced to meet an external user need, and process innovations are defined as new elements introduced into a firm's production or service operation to produce a product or render a service. Product innovations change what the organization offers to the outside world; process innovations change the way the organization produces and delivers those offerings. Product innovations have a market focus and are primarily customer driven; process innovations have an internal focus and are mainly techniques of producing and marketing goods or services. Therefore, while product innovations are embodied in the outputs of an organization and may result in product differentiation or an increase in product quality, process innovations are oriented toward the efficiency or effectiveness of production and may result in a decrease in the cost of production. According to Damanpour (2010) they will have the same antecedents, that is - intellectual capital. So the first hypothesis is that intellectual capital has a strong positive impact on both product and process innovations.

Hypothesis1a: Intellectual capital has a strong positive impact on product innovations.
Hypothesis 1b: Intellectual capital has a strong positive impact on process innovations.

However, in line with Kraft (1990) it is expected to find a strong interrelation between product and process innovations. So, the third hypothesis is:

Hypothesis 2: There is a strong interrelation between products and process innovations.

According to Lee et al. (2011) process innovations are all activities necessary to design and implement a new manufacturing process, or to change an existing process. They can address a range of activities, from relatively minor ''practice-based'' procedural changes to major technological changes, such as the installation of new equipment. Initiatives such as ''Lean'' manufacturing, Six Sigma programs, and technology upgrades. Since by this definition it is highly likely that a company that invests into process change will hire external consultants it is believed that external social capital has a high impact. However, external consultants cannot do the work so structural and internal social capital also play an important role. New procedures have to be put in place changing the structural capital of the company but also workers among them need to cooperate more in order to put changes in place. Product innovations are grounded on knowledge of the workers (human capital) and external social capital as sources of ideas for new products. Of course, internal social capital and structural capital play a role in innovation, but it is supposed that their effect is lower. In line with Menor et al. (2007) that there is a strong interconnection between product and process innovations, because a new product cannot be manufactured unless the production process is adapted for this new product, it is hypothesized that there will be a strong interrelation between product and process innovations. Product innovations will generate revenues, but process innovations do not generate revenue (probably even generate investments costs) but one without the other would not lead to positive results. This is in line with Subramaniam and Youndt (2005) who state that invention is maybe a result from an individual but successful new product is an effort of a whole group. Therefore

hypotheses how each component of intellectual capital influences product and process innovation can be stated as follows:

Hypothesis 3 Human capital has a significant positive effect on product innovation.
Hypothesis 4 External social capital has a significant positive effect on product innovation.
Hypothesis 5 Structural capital has a significant positive effect on process innovations.
Hypothesis 6 Internal social capital has a significant positive effect on process innovations.
Hypothesis 7 External social capital has a significant positive effect on process innovation.

Hypothesis 8 Product innovation has a significant positive effect on revenues from new products.

This study differs in the manner that intellectual capital is described by four components: Human capital, structural capital, external social capital and internal social capital in line with Bueno et al. (2004). Similar results as Menor et al. (2007) are obtained, but the influence of process innovation on innovation output is higher but not direct. Also, it is found that to companies innovation is not as important as quality. If the assumption that an investment into enhancing quality is an incremental innovation and a process innovation, both process and product innovation will lead to higher returns which is the ultimate goal of the company. Therefore, it is expected to obtain that it is noteworthy to invest into intellectual capital of the firm, and that that this leads to positive financial results in terms of profit margin.

Hypothesis 9 Process innovations has a significant positive effect on profit margin.

Methodology

In the sample there are 761 manufacturing companies of which 25,9% are small companies till 50 employees. There are 47% of companies that are middle sized companies (50 till 250 employees) and 27,1% of companies are large with over 250 employees. Countries in the sample are presented in Table 1.

Table 1 -Descriptive statistics of the sample

	Frequency	Percent	Profit margin (% of sales)	Revenues from new products (% of sales)
Australia	74	9,7	21,71	19,68
Canada	4	,5	24,50	13,75
Croatia	113	14,8	18,05	25,21
Czech Republic	1	,1		20,00
Germany	45	5,9	16,33	29,55
Hungary	38	5,0	7,72	20,60
India	58	7,6	23,77	22,63
Ireland	30	3,9	25,05	23,67
Netherlands	2	,3	24,00	12,50
Nigeria	38	5,0	14,07	24,83
Poland	80	10,5	-4,14	26,84

Ukraine	50	6,6	21,10	21,20
USA	148	19,4	15,53	22,34
Vietnam	80	10,5	18,14	71,62
Total	761	100,0	15,05	27,97

Clustering of companies according to profit margin revealed three groups, negative, medium and high performers. However, negative performers can be found even in highest developed countries. It has to be mentioned that negative performers are excluded from further analysis, because the objective of this work is to find best innovation practices. However it has to be noted too, that some performers have above average profit margins yet they have average revenues from new products as for example companies from Canada and Netherlands.

Intellectual capital, product and process innovations are operationalized by latent construct variables using seven-point Likert type multi item scales (strongly disagree=1; strongly agree=7). Measures for each construct are developed from previous literature to assure content validity.

The analysis is conducted using SPSS and AMOS. SPSS is used for descriptive and assessing the Crombach Alpha reliability measures, and post hoc Harman one-factor analysis. AMOS is used for confirmatory factor analysis and evaluating the structural equation model. Table 2 presents the components and model fit.

Table 2 - Constructs, Measurements and factor loadings

		Factor loadings*	Standard error	Critical ratio (t value)
Internal social capital: CR=0.881, AVE=0.654	ISC1	0,584		
	ISC2	0,851	0,10	14,1
	ISC3	0,899	0,10	14,3
	ISC4	0,862	0,11	13,9
Structural (organizational) capital CR=0.883, AVE=0.656	STRUCT1	0,705		
	STRUCT2	0,745	0,08	15,9
	STRUCT3	0,887	0,08	17,8
	STRUCT4	0,886	0,07	18,0
Human Capital CR=0.889, AVE=0.668	HC1	0,826		
	HC2	0,793	0,05	20,3
	HC3	0,878	0,05	22,9
	HC4	0,767	0,05	19,0
External social capital CR=0.901, AVE=0.603	ESC1	0,755		
	ESC2	0,806	0,06	18,9
	ESC3	0,743	0,07	16,5
	ESC4	0,761	0,06	17,2
	ESC5	0,83	0,06	18,4
	ESC6	0,76	0,07	16,7
PROC CR=0.889, AVE=0.573	PROC1	0,756		
	PROC2	0,815	0,06	19,0
	PROC3	0,861	0,06	19,7
	PROC4	0,732	0,06	16,5
	PROC5	0,728	0,07	16,5
	PROC6	0,629	0,06	14,1
PROD CR=0.848, AVE=0.528	PROD1	0,757		

PROD2	0,788	0,05	17,2
PROD3	0,735	0,06	15,5
PROD4	0,708	0,06	15,6
PROD5	0,637	0,06	14,0

$\chi 2$=1513,203, $\chi 2$/df=4,18, p=0, IFI =0,882, CFI =0,881, RMSEA =0,065

Threshold values are all in acceptable range ($\chi 2$/df<5), IFI and CFI>0,8, REMSA<0,1 (Hu and Bentler, 1999). Composite reliability (CR) statistics indicated strong construct reliability in each case; all values are well above 0.7 (Fornell and Larcker 1981). The results establish convergent validity and unidimensionality for each construct, as all item loadings (lambdas) are highly significant (all t-values were >2.0). The results also indicate acceptable discriminant validity for the measures at both the construct and item levels. The average variance extracted (AVE) for each construct variable is greater than the squared correlation of the construct with any other construct, indicating acceptable construct discrimination (Fornell and Larcker 1981). All AVE (convergent validity) are greater >0,5 in line with Hair et al. (2010).

Common method variance is a crucial question when both the dependent and focal explanatory variables are perceptual measures derived from the same respondent. Four approaches have been recommended in the literature as methods that researchers should use to avoid or correct CMV (Chang et al., 2010; Podsakoff et al., 2003), and they have all been fulfilled in this analysis. While conducting the analysis confirmatory factor analysis of the intellectual capital showed distinctive four factors, proving indeed that intellectual capital is a four component construct.

Discussion of results

As can be seen from Table 3. and Figure 2. all components of intellectual capital have a significant positive effect on innovation. Specifically external social/relational capital has a positive and significant impact (0,469) on product innovations. This can be explained as the companies with higher contacts with outside partners especially customers get the information and idea for new product launch. However, in order to achieve a successful launch of a product human capital expressed in knowledge and skills of employees is very important (0,415). Structural capital (0,374) and internal relations among coworkers (0,360) also enhance a probability of a successful new product launch but in a lesser amount than external social capital and human capital.

Table 3 - Interrelations among constructs

			Estimate*
HC	<-->	ESC	0,633
HC	<-->	PROC	0,436
PROD	<-->	ISC	0,360
PROD	<-->	STRUCT	0,374
PROD	<-->	HC	0,415
PROD	<-->	ESC	0,469
PROD	**<-->**	**PROC**	**0,772**

ISC	<-->	STRUCT	0,541
ISC	<-->	HC	0,599
ISC	<-->	ESC	0,539
ISC	<-->	PROC	0,299
STRUCT	<-->	HC	0,598
STRUCT	<-->	ESC	0,604
STRUCT	<-->	PROC	0,375
ESC	<-->	PROC	0,426

**Correlations are all significant at p=0.001 level*

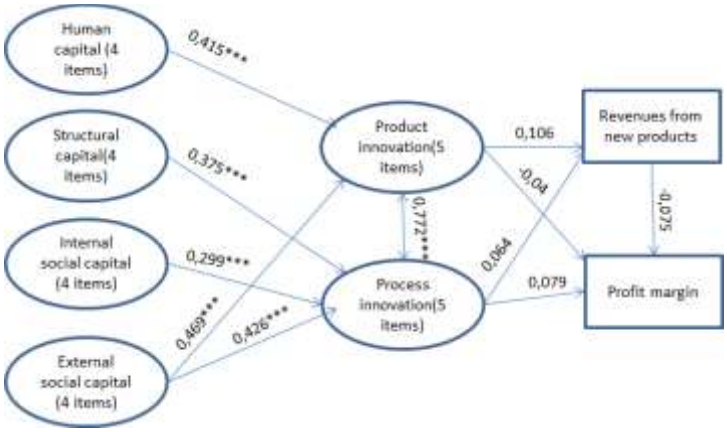

Figure 2 – Model results

From Table 3. it can be seen that all hypotheses Hypothesis 2- Hypothesis 7 are confirmed. The correlation between products and process innovations is c=0.772***. Human capital has a significant positive effect on product innovation (c=0.415***). External social capital has a significant positive effect on product innovation (c=0.469***). Structural capital has a significant positive effect on process innovations (c=0.375***). Internal social capital has a significant positive effect on process innovations (c=0.299***). External social capital has a significant positive effect on process innovation (c=0.426***)

Hypothesis 8 that product innovation have a significant positive effect on revenues from new products (B= 0.106) is partially confirmed. The positive effect is found on revenues from new products but the relationships is not significant, so the hypothesis is only partially supported.
Hypothesis 9 that process innovations have a significant positive effect on profit margin (B=0.079) is also partially supported. Again hypothesis shows a positive relationship but cannot be fully confirmed because relationships is not significant, so the hypothesis is only partially supported.

Conclusion

The model depicted in Figure 2. shows that external social capital has highest impact on product innovations. This is understandable because links with primarily customers will be great source of ideas for new products. But human capital is important too. Without the knowledge and

expertise of employees it would be impossible to create and launch new products. However, it should be noted that internal social capital and structural capital are of no less importance. The knowledge has to be codified in order to be useful throughout the company, and internal social capital is important for launching new products because the launch of a new product will necessities expertise from different departments from the company like marketing, engineering, production and R&D.

For process innovations the dominant effects are again human capital (the knowledge of employees) that will use the technology, external social capital which will transfer the knowledge how to use the new equipment, and structural capital which means that the knowledge of usage of machines is probably codified into manuals that can then be easily accessed and used. Lesser effect on process innovation is internal social capital which is probably due to the fact that employees are experts in usage of part of process technology and do not spend time explaining how to use machines when it is all in manuals.

Product and process innovations are highly correlated, so it proves Kraft (1990) thesis that those two aspects of production should be investigated in parallel.

Finally, it can be concluded from the results that absolutely all four components are important but have different function in process and product innovation.

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